CLAIMS

1. A fault detection system for detecting faults in an aircraft system, the fault detection system comprising:

   a sensor data processor, the sensor data processor receiving turbine sensor data from the aircraft system and augmenting the sensor data to provide augmented data set; and

   a fuzzy logic inference system, the fuzzy logic inference system receiving the augmented data set and analyzing the augmented data set to determine a likelihood that a fault has occurred.

2. The system of claim 1 wherein the sensor data processor augments the sensor data by determining a rate of change of the sensor data.

3. The system of claim 1 wherein the sensor data processor augments the sensor data by generating residuals from the sensor data.

4. The system of claim 1 wherein the sensor data processor augments the sensor data by generating residuals from the sensor data and determining a rate of change of the residuals.

5. The system of claim 1 wherein the sensor data processor augments the sensor data by computing a margin for the sensor data.

6. The system of claim 1 wherein the aircraft system comprises a turbine engine and wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data.

7. The system of claim 1 wherein the aircraft system comprises a turbine engine and wherein the sensor data processor receives exhaust gas temperature data and wherein the sensor data processor augments the exhaust gas temperature data by determining exhaust gas temperature margin data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

8. The system of claim 1 wherein the fuzzy logic inference system includes a plurality of membership functions and wherein each of the plurality of membership functions is associated with at least one data type in the augmented data set, and wherein the fuzzy logic system fuzzifies the augmented data set using the plurality of membership functions.

9. The system of claim 8 wherein the fuzzy logic inference system includes a plurality of rules, and wherein the fuzzy logic system evaluates the fuzzified augmented data set according to the plurality of rules.

10. The system of claim 9 wherein the fuzzy logic inference system further aggregates outputs of the plurality of rules and defuzzifies the aggregated output for input into a diagnostic system.

11. The system of claim 10 wherein the aircraft system comprises a turbine engine and wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor augments the sensor data by generating residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor further augments the sensor data by determining a rate of change of the residuals, and wherein the sensor data processor further augments the sensor data by determining a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

12. A method of detecting faults in a turbine engine, the method comprising the steps of:

    a) receiving turbine sensor data from the turbine engine;

    b) creating an augmented data set from the sensor data;

    c) fuzzifying the augmented data set; and

    d) applying a plurality of fuzzy logic rules to the fuzzy augmented data set to determine a likelihood of a fault in the turbine engine.

13. The method of claim 12 wherein the step of creating an augmented data set comprises determining residuals of the sensor data and determining the slope of the residuals.

14. The method of claim 12 wherein the step of creating an augmented data set comprises computing a margin for the sensor data.

15. The method of claim 12 wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data.

16. The method of claim 12 wherein the sensor data includes exhaust gas temperature data and wherein the step of augmenting the sensor data comprises determining an exhaust gas temperature (EGT) margin from the exhaust gas temperature, the EGT margin corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

17. The method of claim 12 wherein the step of fuzzifying the augmented data set comprises applying the membership functions to the augmented data set.

18. The method of claim 12 wherein the step of applying the plurality of fuzzy logic rules to determine a likelihood of a fault in the turbine engine further comprises aggregating an output of the plurality of fuzzy logic rules.

19. The method of claim 18 wherein the step of applying a plurality of fuzzy logic rules to determine a likelihood of a fault in the turbine engine further comprises defuzzifying the aggregated output for input into a diagnostic system.

20. The method of claim 12 wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the step of creating an augmented data set from the sensor data comprises generating residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the step of creating an augmented data set from the sensor data further comprises determining a rate of change of the residuals, and wherein the step of creating an augmented data set from the sensor data further comprises determining a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

21. A program product comprising:

a) a fault detection program, the fault detection program including:

a sensor data processor, the sensor data processor receiving turbine sensor data from a turbine engine and augmenting the sensor data to provide augmented data set; and

a fuzzy logic inference system, the fuzzy logic inference system receiving the augmented data set and analyzing the augmented data set to determine a likelihood that a fault has occurred; and

b) signal bearing media bearing said program.

22. The program product of claim 21 wherein the signal bearing media comprises recordable media.

23. The program product of claim 21 wherein the signal bearing media comprises transmission media.

24. The program product of claim 21 wherein the sensor data processor augments the sensor data by generating residuals from the sensor data and determining a rate of change of the residuals.

25. The program product of claim 21 wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data

26. The program product of claim 21 wherein the sensor data processor receives exhaust gas temperature data and wherein the sensor data processor augments the exhaust gas temperature data by determining exhaust gas temperature margin data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

27. The program product of claim 21 wherein the fuzzy logic inference system includes a plurality of membership functions and wherein each of the plurality of membership function is associated with at least one data type in the augmented data set, and wherein the fuzzy logic system fuzzifies the augmented data set using the plurality of membership functions.

28. The program product of claim 27 wherein the fuzzy logic inference system includes a plurality of rules, and wherein the fuzzy logic system evaluates the fuzzified augmented data set according to the plurality of rules.

29. The program product of claim 28 wherein the fuzzy logic inference system further aggregates outputs of the plurality of rules and defuzzifies the aggregated output for input into a diagnostic system.

30. The program product of claim 21 wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor augments the sensor data by generating residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor further augments the sensor data by determining a rate of change of the residuals, and wherein the sensor data processor further augments the sensor data by determining a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

31. An apparatus comprising:

a) a processor;

b) a memory coupled to the processor;

c) a fault detection program residing in memory and being executed by the processor, the fault detection program including:

i) a sensor data processor, the sensor data processor receiving turbine sensor data from a turbine engine and augmenting the sensor data to provide augmented data set; and

ii) a fuzzy logic inference system, the fuzzy logic inference system receiving the augmented data set and analyzing the augmented data set to determine a likelihood that a fault has occurred.

32. The apparatus of claim 31 wherein the sensor data processor augments the sensor data by generating residuals from the sensor data and determining a rate of change of the residuals.

33. The apparatus of claim 31 wherein the sensor data comprises engine speed data, fuel flow data and exhaust gas temperature data.

34. The apparatus of claim 31 wherein the sensor data processor receives exhaust gas temperature data and wherein the sensor data processor augments the exhaust gas temperature data by determining exhaust gas temperature margin data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.

35. The apparatus of claim 31 wherein the fuzzy logic inference system includes a plurality of membership functions and wherein each of the plurality of membership functions is associated with at least one data type in the augmented data set, and wherein the fuzzy logic system fuzzifies the augmented data set using the plurality of membership functions.

36. The apparatus of claim 35 wherein the fuzzy logic inference system includes a plurality of rules, and wherein the fuzzy logic system evaluates the fuzzified augmented data set according to the plurality of rules.

37. The apparatus of claim 36 wherein the fuzzy logic inference system further aggregates outputs of the plurality of rules and defuzzifies the aggregated output for input into a diagnostic system.

38. The apparatus of claim 31 wherein the sensor data comprises exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor augments the sensor data by generating residuals from the exhaust gas temperature data, engine speed data, and fuel flow data, and wherein the sensor data processor further augments the sensor data by determining a rate of change of the residuals, and wherein the sensor data processor further augments the sensor data by determining a margin for the exhaust gas temperature data corresponding to a difference between the exhaust gas temperature data and a maximum safe temperature.